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Harnessing the Internet of Things (IoT): A Review

Timothy Malche
JCCC, Jabalpur,
MP, India

Priti Maheshwary
Aisect University, Bhopal,
MP, India

Abstract— Internet of Things (IoT) is an innovative idea which will transform the real world objects into intelligent virtual objects in the near future. The IoT enables user to identify everything in the world uniquely, take control over identified things (e. g. Lights, TV, Door Locks, Microwave, Coffee Maker etc.) and keep informed about the state of things. The term IoT describes several technologies and research disciplines which makes the internet reachable to every real world physical objects. This paper presents concept of IoT through systematic review of research papers. The main objective is to provide an overview of Internet of Things, its applications and operating system for IoT. Many other software services and hardware and network technologies for IoT and their usages are out of the scope of this paper.

Keywords – Internet of Things, IoT, Operating System for IoT, Applications of IoT.

I. INTRODUCTION

The Internet of Things (IoT) is a concept which is outcome of the merged field of computer science and electronics. IoT describes how everyday life objects will interact and communicate with other objects over the internet. In IoT objects are equipped with microcontroller and sensor devices and various software application and suitable protocol stack enable them to talk to other objects. The objects in IoT can be any 'thing' such as people, devices, animal, building, vehicle or any physical thing which is part of our daily life. IoT is everything-to-everything communication. In general IoT can be described as a combination of Sensors, Connectivity and People & Processes. IoT combines smart devices with smart services to create compound applications for example intelligent transportation, smart cities, smart healthcare, smart home, smart building, digital farm, smart agricultural etc. IoT delivers on demand real-time services and assists in saving time, resources and even manpower. This comprehensive literature review explores the impact of IoT technology in several fields.

II. APPLICATIONS OF IoT

The applications of IoT may be huge in numbers and more research is going on at present on harnessing the IoT. However in this paper **I** will try to discuss some of the applications of IoT based on literature survey.

Modern buildings around the world are becoming more complex in terms of infrastructures and facilities and other services the need for an intelligent system to cope with any emergency situation is also growing. Chang-Su Ryu [1] has described IoT based Fire Emergency Response System which is one such solution and is reliable and safe and will be used to minimize human causality in an emergency situation. The system uses detection sensors which will be used for the recognition of fire and Wireless Sensor Network for the communication between sensor devices and the system. The system facilitate in quick and safe evacuation out of the building exits during emergency. The Fire Judge Module of the system alters the evacuation directions according to the situation and location of the fire through intelligent evacuation equipment. The system controls the direction of the guidance lights for the intelligent optimal evacuation by designing the path to evacuation locations through various detours depending on situational conditions. The emergency lights in this system are powered by cable wiring and batteries and contain detectors for smoke, flame, and heat and h as bidirectional indicators that communicate via the WSN. This system also has a smartphone app to alert evacuees of the building in case of emergency and allow evacuees to check their location and the evacuation path who could not escape by following the emergency lights and whose visibility is obstructed by some condition like smoke.

P. Elanthiraiyan et al [2] and Alok Kulkarni et al [3] presented how Internet of Things (IoT) can be most efficiently used in distant health monitoring and emergency healthcare systems. IoT makes healthcare system more useful, informative and effective. Healthcare System using IoT enable health monitoring from remote location. The system is divided into three layers. The first layer is the Human machine interaction and second layer is multidisciplinary optimizations which are formed in the many operations on the system architecture. And third layer is managing the applications by the database and class mapping in the knowledge base. The Human machine interaction can be achieved by the base of the resources (e.g. such the RFID, ambulance, medical resources) and human (e.g. doctors, nurse and patients). With this system the quality of care is improved through monitoring patient status to achieve constant attention. A variety of sensors are used to input data and algorithms to analyze the data. IoT based healthcare system is efficient in providing the healthcare services to patient's and can also assist doctors and other staff in the hospital or where the service is required.

Jebah Jaykumar et al [4] described Radio Frequency Identification (RFID) as one of the key technologies used in IoT to exchange information. The RFID technology can be used to sense objects and then to transfer information about the

objects on the networked computer where further processing can be done. RFID technology uses RFID tags. There are three types of RFID tags, active, semi-passive and passive. Since security is the major concern in the communication between objects in IoT, the RFID technology can be effectively used to develop a model for secure communication between these objects. One such example of RFID powered IoT is Electronic Product Code Information system (EPC-IS) and shop server at shopping mall where secure communication between its objects can be achieved.

Another example of RFID given by Kadlec et al [5] is real time hospital laundry management application for detection and identification of monitored objects for hospital laundry management. The architecture of RFID Laundry Inventory System has three layers, Data Access Layer, Business Logic Layer, and Application Layer. The system uses RFID technology at data access layer and a secure communication is performed with other two layers of the system. The Business Logic Layer (BLL) is the core part of this system which is responsible for processing data from the Data Access Layer. It processes the data received from RFID readers. It also contains database system for archiving data. Application Layer performs post–processing operations. The overall system provides secure communication which is ensured by several security mechanisms at a communication and application level.

Menon et al [6] described how the Bus Transport system based on IoT will be extremely helpful to overcome the problem faced by the existing transportation system in Singapore. The Bus Transport system will consists of either Radio Frequency Identification (RFID) or Bluetooth Low Frequency (BLE) sensors, embedded device to collect the information about passengers, bus and its routes. It uses Satellite to transmit signals and Mobile Phone App to access services and a cloud server.

Guohong Li et al [7] introduced ZigBee as another simpler and less expensive technology for IoT. ZigBee technology can be implemented in agricultural and greenhouse monitoring system. ZigBee node devices consume less energy and are low cost and are best suitable for greenhouse. Researchers have also described the implementation of µC/OS for devices in the greenhouse system. The IOT Gateway based greenhouse system is designed for real-time monitoring and controlling of greenhouse system to improve production and management.

Apart from sensors and communication technologies, cloud services are also has major role to play in IoT. IoT can not be imagined without cloud. There are many cloud services available today. Daniel Palma et al [8] explained implementation of Xively cloud services for IoT. Xively is a new cloud platform which provides an environment for devices to connect to one another in IoT. Classroom Access Control is the IoT application implemented over Xively. Classroom access control provides authorized access to classroom and to display real time status of classrooms. The system is equipped with Arduino device which uses RF to identify the user accessing the classroom. The data is then submitted to the cloud, transferring the information about teacher and classroom to the server platform Xively. From this stored data two applications are created one which uses Google map to display information of classroom and other which uses Zapier tool to publish data on social network.

H. Bhide [9] presented IoT based Smart Home to increases quality of life and improve reliability, comfort, convenience and security. In a Smart Home a PC monitors various household devices and controls them and sends data to the cloud server. The IoT based Smart Home allows a person to control and monitor home activity such as lighting, heating, air-condition, security locks etc. from remote location. IoT based smart home also helps in accessing to services automatically whenever required. For example it predicts if there is a need for maintenance of some device and sends the notification to registered technician through cloud server automatically. This system provides complete home automation.

So far we have seen how IoT is used in various fields which help to make living more secure, reliable, managed and controlled. We can also harness the power of IoT at large scale. Zanella et al [10] explained IoT based Smart City as the example which may include all the above discussed IoT enabled fields of our life. The Padova Smart City, Italy is the example of IoT based Smart City. This Smart City contain several services such as for Automation of public buildings, Waste Management, smart health services, air and noise pollution monitoring and controlling, Traffic Congestion monitoring and control, City Energy Consumption management, Smart Parking services, Smart Grid etc.

These are the few examples of how we can harness the power of IoT in our lives. If we take an example of Internet in today's scenario, it becomes sometimes very hard for us to imagine our everyday life without the internet. Similarly in future it will be hard for us to imagine our lives without objects connected to internet. That is the IoT for us where internet not only the network of computers or smartphones but it will be internet of every thing in our world.

III. OVERVIEW OF OPERATING SYSTEM FOR IoT

IoT includes wide range of machines from sensors powered by microcontrollers to other devices and sensors powered by processors which has similar capability as we have those in smartphones. As more and more devices are getting connected to IoT the need for operating services are also increasing. The traditional operating system and OS for sensor network cannot fulfill diverse requirement of the devices connected to IoT [11]. The devices in IoT need to be up and connected to network and other devices all the time in order to transmit and receive real-time data. For such a Real-Time Operating System is required which can manage low energy devices which can run continuously for a year or more on AA battery or other low powered sources. Currently many operating systems for IoT are in use which supports many devices.

Contiki [12] is an open source operating system for the Internet of Things. Contiki connects tiny low-cost, low-power microcontrollers to the Internet. It provides fast and easy development. Applications are written in standard C language. It is free for in commercial and non-commercial systems with full source code. Contiki supports wide range of platform and can be easily ported to new platform.

mbed OS [13] is an operating system for IoT devices. It is especially designed to run in low cost energy environment. The OS provides connectivity, security and device management functionalities required by IoT devices. It provides C++ application framework for application development and supports all the key open standards for connectivity and device management.

TinyOS [14] is a free and open source software component-based operating system for IoT. TinyOS is for low-power wireless devices, such as those used in sensor networks, ubiquitous computing, personal area networks, smart buildings, and smart meters.

µC/OS (MicroC/OS) [15] is the real-time operating system for the embedded devices used in IoT. It support wide range of microcontroller devices and designed for low energy devices.

RIOT [16] is an operating system for Internet of Things (IoT) devices which is most popular and reliable today. It is based on a microkernel. RIOT is designed for energy efficiency and supports hardware independent development. RIOT is the only OS that provides a high degree of modularity for IoT devices. This OS also have built in multithreaded support which manage devices resources more efficiently. RIOT provides C/C++ framework for application development.

Brillo [17] is the entirely new Operating System for IoT introduced by Google in may 2015. With the growing rate of Android platform Google now intends to reach more diverse devices. Brillo is based on the lower levels of Android which can run on minimal system requirements. It is perfect for devices like lightbulbs etc. Brillo offers a protocol for synchronizing data between devices called Weave - a cross-platform common language similar to JSON. Google is planning to introduce weave API and development platform later this year. With weave a Brillo device can talk to each other and cloud and also able to identify other devices such as android phone on the Internet.

The OS for IoT devices is the most important software for IoT infrastructure. Take an example where OS might be installed in streetlights in a city to identify when the lights need to be on or off to help save electricity. The OS for IoT devices opens up wide area for research in the development of various kinds of OS services. The OS on the IoT devices will help make them smarter thus kind of services need to be developed for such OS. It will also open opportunity to create an environment similar to Google play services and Google store for the IoT devices so the device can be notified and services can be updated or installed intelligently on such devices whenever required.

IV. PLATFORM FOR IoT

Collecting data from sensor devices and sending it to cloud server for processing and store it for future use is one of the major task of the IoT system. For this purpose a cloud server must be loaded with services which communicate with such devices and offer data management, application development and other data related services. Following are some of the platform which enable user to build such services.

Xively [18] is an enterprise IoT platform and application solution. Xively enables users to connect their devices to IoT and help manage connected things. Xively offers secure, scalable and reliable connectivity. It also helps in building business applications and data processing services. Xively provides liberary for device connectivity, discovery and management and SDKs for application development for the devices and cloud services for data management and integration.

Kaa [19] is an Open Source middleware platform for IoT. Kaa is a reliable and secure platform for developing connected things. It also offers custmizable middleware platform. Kaa is free to use and it can be deployed anywhere including cloud. Kaa supports variety of hardware devices. Kaa offers SDKs which can be embedded into many devices. Kaa platform consists of hardware platform, Data Model, SDK, Connectivity services, the Kaa server, Data Processing services and application development platform. Kaa offers secure communication for devices via AES-encrypted TCP based binary protocol. Kaa SDK available in C/C++ and java which can be embedded in client application on firmware and can perform client/server communication. Kaa server is the main foundation for IoT enabled system. Kaa server provide data management, integration, visualization and many other data related services. Kaa Data Processing services helps in collecting data from the connected devices which is one of the crucial task in the IoT world. For this it supports many data services of choice such as mongoDB, Hadoop, Spark, Oracle DB etc.

IBM Bluemix [20] is a digital innovation platform for IoT. It is a set of application centric runtime environment, IBM containers and virtual machines which enables user to build services for IoT system. It also helps to extend the application functionality by implementing the IBM, third-party, and community services which can be securely connected to Bluemix.It also offer flexible scaling of computational power and collaboration of source code and shared APIs. Bluemix also enable users to deploy and manage hybrid applications which can be on public, personal, and local Bluemix instances. it helps users to integrate application and system running elsewhere via secure environment and share and synchronize data and to create and expose enterprise APIs. Bluemix provide open architecture solutions for IoT.

Carriots [21] is a Platform an a Service (Paas) which is designed for IoT. Carriots allows user to collect data from various devices, store it and build power applications using SDK engine and deploy and scale services to variety of devices. It provide powerful API and web services to integrate application with the external system. With Carriots user can build simple, reliable, scalable, fast, secure and low cost services for the IoT system. Carriots provides rich set of REST API and powerful Groovy SDK. Carriots helps in maintaining, controlling and interacting with devices remotely and even change its configuration. Its built in alarm also notify when there is something wrong in the system. It provides API key management services and custom control panal where user can manage all Carriots entities.

Nimbits [22] is open platform that allow users to store sensor data on cloud. Nimbits platfor consists of Nimbits Server, nimbits.io, Nimbits Android and Nimbits public cloud. Nimbits Server enable users to record, store and process data

from IoT sensor devices and define and execute business rules. nimbits.io is an open source java library that enable users to build software for IoT. Nimbits Android is an application developed using nimbits.io and available on google play which offer many features of nimbits client.Nimbits public cloud is the instance of Nimbits server. Nimbits server can be installed on chip, server and cloud. It enables user to control, manage and monitor IoT devices from cloud.

V. CONCLUSION

IoT technology is a recent paradigm which is gaining popularity. It is estimated that there will be 5 billion connected objects by the end of year 2015 and 25 billion connected objects by year 2020 supporting total services spending of $69.5 billion in 2015 and estimated $263 billion by 2020. We are heading toward future where there will be many connected objects per person. Although IoT technology is in initial stage but soon it will transform future and the way we live. It is the technology of future. Just like smartphones have made a big change in the way we communicate and deliver information with the help of large number of application available. Soon IoT technology will also bring big change in the way we live and interact with the world like we have never thought before. IoT offers vast area of research in many fields. This literature review will help researchers to understand concept and implementation of IoT and will help to continue further research work in IoT. The research directions [23] in IoT includes Massive Scaling, Architecture and Dependencies, Creating Knowledge and Big Data, Robustness, Openness, Security, Privacy, Humans in the Loop, Software and Algorithms, Network and Communication Technologies, Hardware Technology, Power and Energy Storage Technologies, Data Signal and Processing Technology, Discovery and Search Engine Technology, Standardization.

REFERENCES

[1] Chang-Su Ryu, "IoT-based Intelligent for Fire Emergency Response Systems", International Journal of Smart Home,Vol. 9, No. 3 (2015), pp. 161-168.
[2] P. Elanthiraiyan, Dr. S.Babu, "Smart Medicine and Physical Health System Using IoT", IJCSMC, Vol. 4 Issue 3, March- 2015, pp. 333-338
[3] Alok Kulkarni, Sampada Sathe, "Healthcare applications of the Internet of Things: A Review", IJCSIT, Vol. 5 (5), 2014, pp. 6229-6232.
[4] Jebah Jaykumar, Abishlin Blessy, "Secure Smart Environment Using IOT based on RFID", IJCSIT, Vol. 5 (2), 2014, pp. 2493-2496.
[5] Jaroslav Kadlec, Radek Kuchta, Radovan Novotný and Ondřej Čožík, "RFID Modular System for the Internet of Things (IoT)", Industrial Engineering & Management, vol. 3, issue 4, 2014, pp. 1-7.
[6] Menon, R. Sinha, D. Ediga, Prof. Subba Iyer, "Implementation Of Internet Of Things In Bus Transport System Of Singapore", Asian Journal of Engineering Research, Vol. I, Issue IV, July-Sept. 2013, pp. 08-17.
[7] Guohong Li, Wenjing Zhang, Yi Zhang, "A Design of the IOT Gateway for Agricultural Greenhouse", Sensors & Transducers, Vol. 172, Issue 6, June 2014, pp. 75-80.
[8] Daniel Palma, Juan Enrique Agudo , Héctor Sánchez and Miguel Macías Macías , "An Internet of Things Example: Classrooms Access Control over Near Field Communication", Sensors 2014, 14, pp. 6998-7012.
[9] H. Bhide , "A Survey on the Smart Homes using Internet of Things (IoT)", IJARCSMS, Volume 2, Issue 12, December 2014, pp. 243-246.
[10] Andrea Zanella, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, Michele Zorzi, "Internet of Things for Smart Cities", IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 1, FEBRUARY 2014, pp. 22-32.
[11] Emmanuel Baccelli, Oliver Hahm, Mesut G¨unes, Matthias W¨ahlisch, Thomas C. Schmidt HAW Hamburg, "Operating Systems for the IoT – Goals, Challenges, and Solutions", ResearchGate, January 2013, pp. 1-6.
[12] http://www.contiki.com/
[13] https://mbed.org/
[14] https://en.wikipedia.org/wiki/TinyOS
[15] http://micrium.com/rtos/ucosiii/overview/
[16] http://www.riot-os.org/
[17] https://developers.google.com/brillo/?hl=en
[18] https://xively.com/
[19] http://www.kaaproject.org/
[20] http://www.ibm.com/bluemix/
[21] https://www.carriots.com/
[22] http://www.nimbits.com/index.jsp
[23] John A. Stankovic, "Research Directions for the Internet of Things", IEEE, 2014.

